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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ice nucleation by combustion ash particles at conditions relevant to mixed-phase clouds" *by* N. S. Umo et al.

Anonymous Referee #1

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The study presented by Umo and co-authors is a timely work about the ice nucleation activity of different kinds of ashes. Ashes are one of the open issues as far as ice nucleation is concerned, and not many studies exist on this topic, so far. The study gives a good overview of the basics concerning the topic, and then gives a solid description of the examinations which were done. The examined ashes were not only analyzed with respect to their ice nucleation ability in immersion freezing, but also characterized in other aspects as e.g. surface area, size distribution, mineralogy and composition.

The emerging picture is, that ashes in general are ice active in a comparable manner to the ice activity of some mineral dusts, and that particularly coal fly ash as produced and emitted by power plants is ice active already at comparably high temperatures.

This study might be seen as a starting point for future research on the topic of the ice activity of ashes. It is well written, and besides a few technical comments I give below, I have no concerns and would, after the below mentioned issues are removed, suggest this study for publication in ACP.

Technical comments:

p. 28847, line 11: The citation of "Vali et al., 2014" relates to the discussion version of this paper, and I generally recommend to refrain from citing these versions as they are not peer reviewed, yet. Moreover, it was discussed in the discussion of this paper that particularly condensation freezing was not well defined. There is a paper by Wex et al. (2014), which, in its appendix, provides a short overview of the variety of definitions of condensation freezing present in literature

p. 28847, line 13: replace "(0 - - 36°C) " with "(0 to -36°C)"

p. 28849, line 14: add "identified as" in front of "carbonaceous-mineral"

p. 28851, line 6: When reading "known mass" twice in this sentence, I wondered how much that might have been. Later I understood that the concentrations are given in the respective figures. Please mention already here that different concentrations were examined and that these values will be given later.

p. 28851, line 23: Mention explicitly how many droplets were examined.

p. 28852, line 9-15: You mention sieving the samples, prior to further analysis. Were also those samples sieved, that were used for the suspension examined in the freezing experiments? Please state explicitly, somewhere in the text dealing with preparations of the suspensions, if they were or were not sieved. This also connects to the values given in Table 2, where the data for the CFA bulk was different from that of the sieved CFA. I can only imagine that this is the case if some material is lost through sieving, but you make it sound (see also the following remark), that all of the CFA passes through the 40 micrometer sieve. Please explain clearly somewhere, where the difference in

the composition of bulk and sieved CFA came from.

p. 28852, line 13: It is clear what you want to say here, with "that at least two dimensions of the particles were smaller than 40 micrometer", but I had to think about this sentence twice before I got it. Maybe you can find an alternative way of phrasing it?

p. 28854, line 4 and line 14: You mention size distribution measurements in this chapter, and in Fig. 3, these are shown. From Fig. 3 it seems that these size distributions are expressed in terms of volume fractions per channel. Please mention this explicitly in the text, as it makes a large difference if it is shown related to particle diameter or surface area or volume.

p. 28854, line 11: Are the average volume diameters you derive here compatible with what is shown in the SEM pictures? There you gave a value of 5 micrometer for CFA, and the difference likely originates in the different reported values (where it is the average volume diameter for the laser diffraction measurements), but this should be discussed in a sentence or two.

p. 28855, line 2: The ";" should be a ","

p. 28855, line 6: Insert "in" between "used" and "this study"

p. 28856, line 25: To might want to explain here that this experimental limitation originates from the fact that there is a larger amount of material (ash in this case) present, per droplet, in the micro-liter experiments, increasing the probability of ice nucleation and hence already causing all droplets to freeze at higher temperatures, compared to droplets that contain less material.

p. 28857, line 18-20: The citations given here are in parenthesis (opening in line 18, closing in line 20), and these parenthesis should be removed.

p. 28860, line 25: It would be interesting to see the parameterization by Augustin-Bauditz et al. (2014), which you mention in the text, in Figure 8, too (the "clay baseline"). Please add the line mention it in the caption and the legend.

p.28866, line 23 and line 27: DeMott needs a capital "M". There are also other occurrences of this name in the references, sometimes with a capital "M", sometimes without. Just go though the whole list and correct it.

Figures: Often the legends and other text (e.g. elements in Fig. 4) are MUCH too small to be decipherable (e.g., I had to blow Fig. 7 up to 300% before I could see the concentrations). Please check all of your plots and change them such that they will be readable when printed, and while doing so take into consideration if you want a particular plot to have a single or double column width.

Figure 6: You mention a run done with pico-liter droplets which I can't find mentioned in the legends. Please correct.

Figure 8: You'd have done me and future readers a favor if you had sorted the entries in the legend following their "appearance", e.g., from "top to bottom", at least within each category (e.g., within the mineral dust measurements), mentioning first the K-feldspar, then the Na/Ca-feldspar, then quartz, ... - particularly for those datasets that are all close to each other, this helps to identify the symbols.

Literatur:

Wex, H., P. J. DeMott, Y. Tobo, S. Hartmann, M. Rösch, T. Clauss, L. Tomsche, D. Niedermeier, and F. Stratmann (2014), Kaolinite particles as ice nuclei: learning from the use of different kaolinite samples and different coatings, Atmos. Chem. Phys., 14, 5529-5546, doi:10.5194/acp-14-5529-2014.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 28845, 2014.